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COUNTRY Hungary/China

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1. [redacted] report, in English and Chinese, on the measurement of telluric currents between Sopron, Hungary, and Peiping, China, made in January 1956.

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2. Professor CHAO Chiu-chang, also known as JAW Jeon-jang, is known as director of the Institute of Geophysics and Meteorology, Chinese Communist Academy of Science, as of early 1956.

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INFORMATION REPORT INFORMATION REPORT

地球物理學報
第5卷 第2期 1956 年12月

RESULTS OF THE SIMULTANEOUS MEASUREMENTS OF TELLURIC CURRENTS BETWEEN PEKING (CHINA) AND SOPRON (HUNGARY) EXECUTED FROM 9TH TO 14TH JANUARY 1956

K. KÁNTÁS*

The investigations of the field of telluric currents and of their variations have received an impulse in the recent past. It was a recognition of C. et M. Schlumberger that telluric currents are the basis of a new important geophysical research method, the attention has been called to the examination of the nature of these currents and to their relation with Earth's magnetism and atmospheric electricity. The fundamental paper in this territory of the research which also includes the investigation of oscillations of the telluric current, is the dissertation of M. Schlumberger and of G. Kunetz.[1] This paper was based upon the measurements of telluric currents executed between France and Madagascar. Very important results are contained in the work of G. Kunetz,[2] where the records of those measurements are evaluated which have been carried out on six points of the Earth on the occasion of the eclipse of the Sun on February 25th, 1952. The aim of our measurements was partly to confirm the results contained in the above mentioned papers and to verify the identical origin of the oscillations of telluric current in the current-flows in Europe and in Asia, and partly to supply further data for the investigations.

The recording organ of the instrument was a Picard-type mirror galvanometer, "antivibratoir immergé". The period of the galvanometer was about 1 sec, therefore it is suitable for the registration of telluric oscillations too, the period of which is a few sec. The sensitivity of the galvanometer was 1×10^{-9} a/mm/m. The velocity of recording was 2 cm/min. The time signal was given by a contact chronometer. The course of the chronometer was controlled by ONOGO-signals and therefore the accuracy of time-measuring was about 1 sec. The ONOGO-signals were supplied in Peking by the broadcast station of Shanghai, in Sopron by the BBC of London. The directions of the lines at both stations were in magnetic N-S and E-W. The registration was carried out daily from the 9th to the 14th January 1956, from 6^h to 9^h G.M.T. (Greenwich Mean Time).

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The regularity of the mean daily level change of the telluric currents for all stations measured was stated by G. Kunetz, therefore, instead of whole-day recording, short-time observations have been carried out during some days (3 hours per day).

In the course of evaluation the following data have been studied:

(1) The vector-diagram of the rapid-variations in the records of both stations, to throw light on the directions of the current-flow;

(2) The change of mean levels in a time-interval of 10 minutes, by means of two different statistical methods;

(3) Frequency connections by means of (simple) scaling of frequencies.

The character of the activity of both stations is, generally speaking, the same. The oscillations or pulsations of greater periods appear simultaneously. In the course of both records taken on January 9th (Fig. 1, p. 80), the activity ceased at the same time ($7^h\ 26^m$). It is remarkable that the 1-min-bay appearing in the record of Peking at $7^h\ 27^m$ has no equivalent in the record of Sopron. It might be useful to compare this result with the magnetogram of Peking. The changes in the magnitude appear also simultaneously, of course the amplitude of identic-frequency oscillations grows from the 13th to the 14th January (Fig. 2a & 2b, p. 81—82). The scaling of frequency has, in some parts of the records, given identical results in short intervals too, but this is not sufficient for the purpose of generalization and of phase-correlation. In general, the periods with 20—25 sec. agreed best.

Detailed analysis of the results

(1) For the construction of vector diagrams, 1-min. time-intervals with all their changes have been used in the records of January 14th. Results proved that while in Sopron the vector of field intensity was revolving and the direction of revolution could well be recorded, the current direction in Peking was nearly constant in the N—NE direction (Fig. 3a & 3b, p. 84) (We wish to remark that we had the same experience in China in the course of our field measurements in Shangtung). As we cannot speak of the direction of revolution of the field intensity vector in Peking, this parameter cannot be used.

(2) The average levels have been investigated by means of two methods:

(a) We have determined the total change vectors daily, in time intervals of 10^m, between 7^h and 8^h, by means of the following equations:

$$V_x = \int_{t_1}^{t_2} \left| \frac{dX}{dt} \right| dt, \quad V_y = \int_{t_1}^{t_2} \left| \frac{dY}{dt} \right| dt, \quad \text{and} \quad V = \sqrt{V_x^2 + V_y^2}$$

(b) As this method puts special stress on the rapid variations, we have, upon proposal of A. Ádám, introduced the following method:

$$T_x = k_x \sum_{n=0}^{i} \left| \int_{t_n}^{t_{n+1}} dV_x \cdot dt \right| \cdot mV \cdot \sec$$

and $T_y = k_y \sum_{n=0}^{i} \left| \int_{t_n}^{t_n+1} dV_y \cdot dt \right| \cdot mV \cdot \sec$

(of course $i=10$ min.),

$$T = \sqrt{T_x^2 + T_y^2},$$

where $k = \Delta V \cdot \Delta t\ m\ V$ sec/mm², a calculating coefficient. This method is in favour of the slower changes; its drawback is that it is very sensitive with regard to accuracy of planimetry and to the polarization course of the electrodes.

If we compare the relative changes of the average levels gained on the two stations by means of the total method in a time-interval of 10^m, we can see that, not considering a few exceptions, the level-change occurs in identic directions (Fig. 4, p. 85). The purely qualitative resemblance shifts sometimes also over to a quantitative connection and the changes expressed in precentage are also identical. Our above observations are confirmed also by the curve of daily average values (Fig. 5, p. 85). This curve shows on both stations a peak value on January 10th, decreases till January 13th, then increases again. It can be seen from the records that the changes appearing in the levels depend chiefly upon the number of oscillations. It was proved by Kunetz that the telluric current changes extending over the whole Earth occur in the frequency band corresponding to the periods of abt. 20 sec, that is between the oscillations. This seems to be proved also by our measurements carried out with the parallelism of the changes.

From the daily average values of the total change vector we receive as middle value of the correlation factor: $l = \frac{V_{\text{Peking}}}{V_{\text{Sopron}}} = 4.8$. Maximum tolerancy is ± 1.4, uncertainty therefore is abt. 30%.

The area method of Ádám has not brought about such good correlation, while a correspondent for the long-period changes was often searched for in vain on the records of the other station. (Fig. 6, p. 86). The relative level changes are often different and the daily average values again show the same fluctuation also with the area method (Fig. 7, p. 86), as with the total method, if we take out from the Peking values those of January 12th. On the other days: $l' = \frac{V_{\text{Peking}}}{V_{\text{Sopron}}} = 3.14 \pm 0.19$, which means that uncertainty is only 6%.

(3) The counting of frequency has also been made in time intervals of 10 min., during identical periods (Fig. 8, p. 87). The agreement is very good, also as regards details. Comparing the changes of relative frequency with the fluctuation of the total change vector, it can be seen whether the decrease or increase of the latter is in connection with the frequency or amplitude-change. During the observation the daily average values at frequency numbers are, on the whole, changing similarly, and support therefore our former statements on this territory.

According to statistical calculations, part-correlations are not exceptional phenomena, but have a very sound, far-reaching foundation. The changes measured during several days of the oscillation average values show that the general effect of noise sources can equally be observed in Peking and in Sopron, the fine changes, however, can, in consequence of the great distance, be identified only now and then.

Our investigations have been carried on with regard to oscillation activity only, as the impulse-like changes which extend over the whole Earth, did not appear on our records, and by chosing such a short space of time for our observations, we have given up beforehand the study of the global activity of the Sun depending upon local time.

Measurements in Peking have been carried out by Eng. A. Ádám and Eng. E. Takács, assisted by comrades of the Chinese Academy of Sciences and Ministry of Geology. In Sopron, the observation has alternately been carried out by Eng. P. Bencze, F. Béldi, B. Ruzsa and P. Egerszegi.

We owe deep gratitude to the presidium of the Chinese Academy of Sciences who have opened up the way for the carrying out of these scientific works; thanks are due to the Geophysical Chief Department of the Chinese Ministry of Geology; without their help and support, this measuring work could not have been carried out. Finally I express my heartfelt gratitude to Professor Jaw Jeou Jang, Director of the Geophysical Institute of the Academy, for having rendered it possible to carry out measurements in the Peking Observatory.

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[1] M. Schlumberger et G. Kunetz: Variations rapides simultanées du champ tellurique en France et à Madagascar, C. R. Acad. Sc. Paris, 1946, t. 223, p. 551—553.

[2] G. Kunetz: Enregistrements des courants telluriques a l'occasion de l'éclipse de soleil du 25 février, 1952.

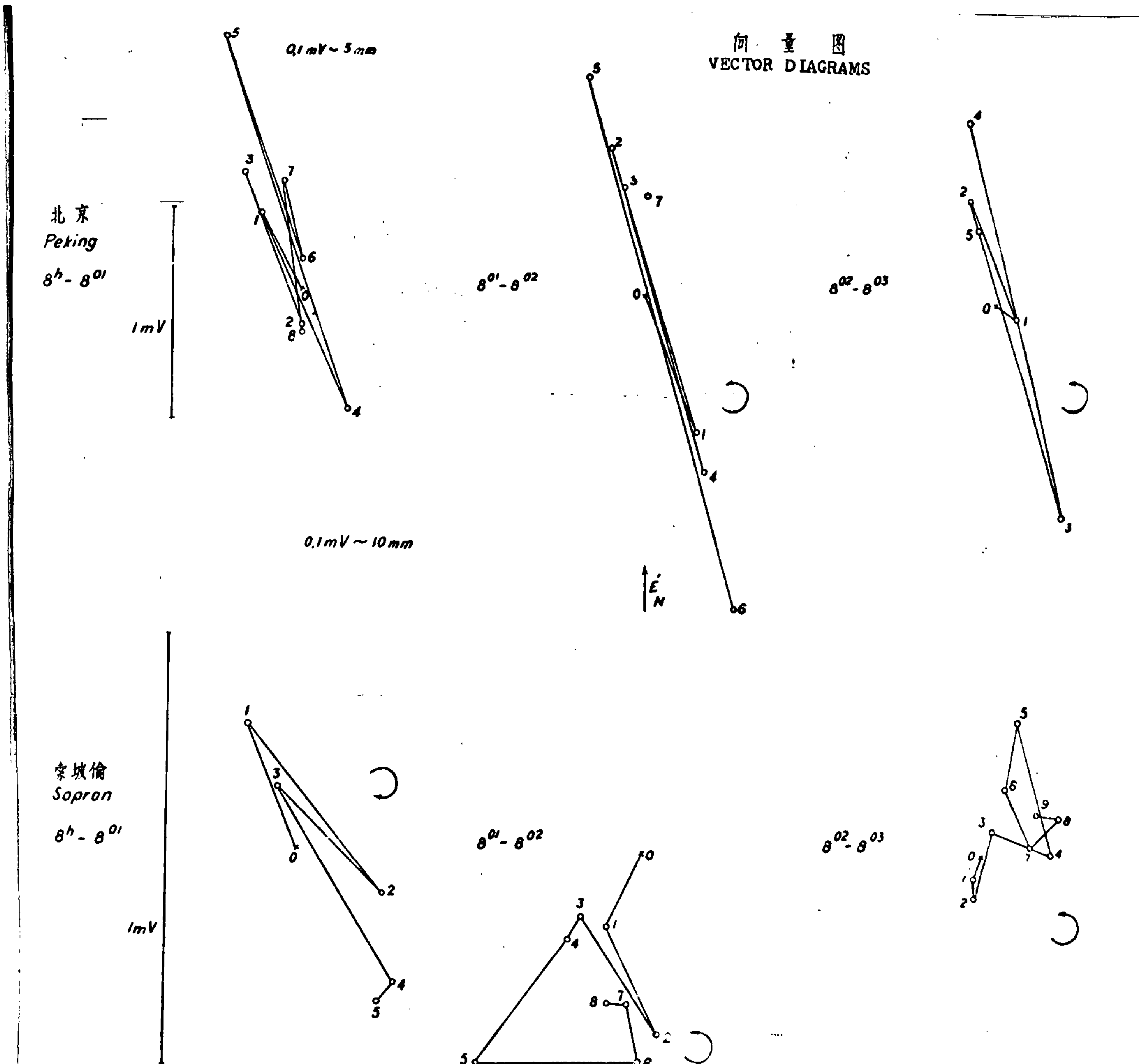

图 3b. (Fig. 3b.)

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地球物理學報

第5卷 第2期 1956年12月

1956年1月9日至14日在中國的北京和匈牙利的索坡倫兩處同時觀測大地電流的結果

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在不久以前關於大地電流場的研究曾受到了一番鼓舞. C. 和 M. 斯郎波澤曾指出大地電流是一個新的地球物理勘探法的基礎，因此人們已經注意研究這些電流的本質和它們與地磁及天電的關係. 關於這一方面的基本文獻是 M. 斯郎波澤和 G. 孔涅兹的論文[1]，在此論文裏也包含着關於大地電流的振盪的研究。這篇論文是根據在法國和馬達加斯加島上作的大地電流的觀測而寫的. 以後 G. 孔涅兹的著作裏曾把 1952 年 2 月 25 日的日蝕期間在地球上六個地點觀測大地電流的結果加以分析研究並得出了重要的結論[2]. 我們的研究的目的一方面是要證實上述文獻裏提到的結果，和證實歐洲和亞洲的大地電流的振盪有着同一個根源；另外一方面也還想爲大地電流的研究再積累一點數據。

我們用的記錄儀器的主要部分是一個派卡得型的光點電流計，用油浸法減低自由振動. 電流計的週期是1秒，所以爲了記錄週期爲數秒的大地電流的變化是很合適的。電流計的靈敏度是 1×10^{-9} 安/毫米/米；記錄的速度是 2 厘米/分鐘。記錄的時間訊號是由一個接觸時計送出來的. 時計的快慢則是用由無線電台放出的國際時刻訊號來校準的，因此在記錄上度量時間的精確度可達到1秒. 在北京接收的是上海徐家匯的時刻訊號，而在索坡倫則是收聽的倫敦 BBC 電台. 在兩處的觀測電極都是沿着磁的南北和東西按放的. 觀測的日期是從 1956 年 1 月 9 日至 14 日，時間是每天從世界時 6 點到 9 點.

G. 孔涅兹曾提到在各地的觀測台上大地電流平均強度級的日變規律性，因此我們就沒有作整天的觀測，而是在這些天內每天僅觀測三小時.

整理和分析結果的時候我們曾研究了：

（1）兩處記錄下來的快速變化的向量圖，以便對電流的流向提供線索；

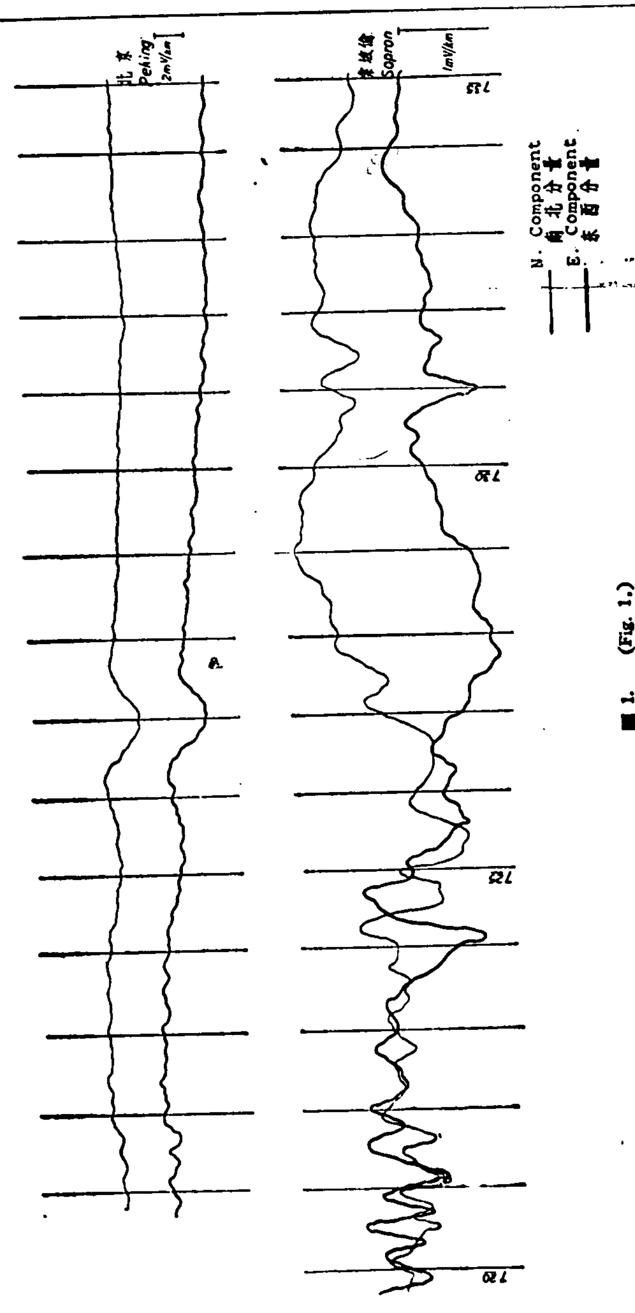

北京
Peking
2mV/km
索波倫
Sopron
1mV/km
N. Component 南北分量
E. Component 東西分量

圖 1. (Fig. 1.)

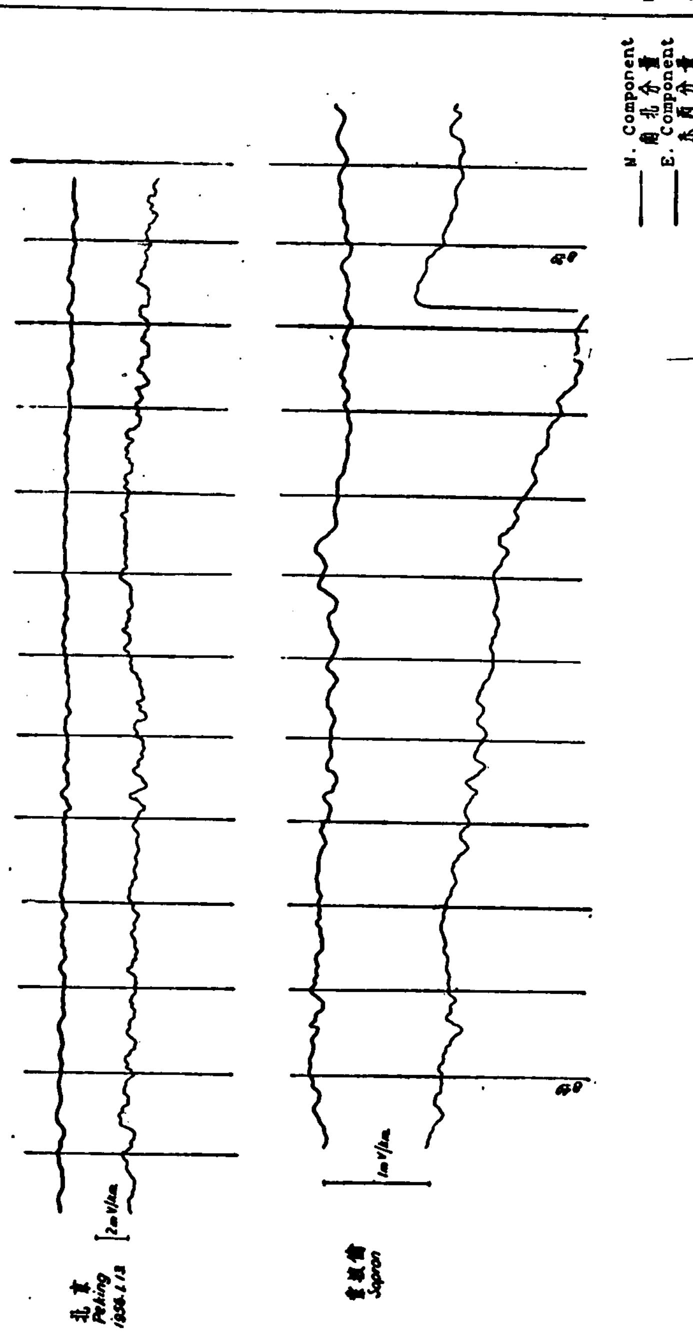

N. Component 南北分量
E. Component 東西分量
1mV/km
2mV/km
北京 Peking
索波倫 Sopron

圖 2a. (Fig. 2a.)

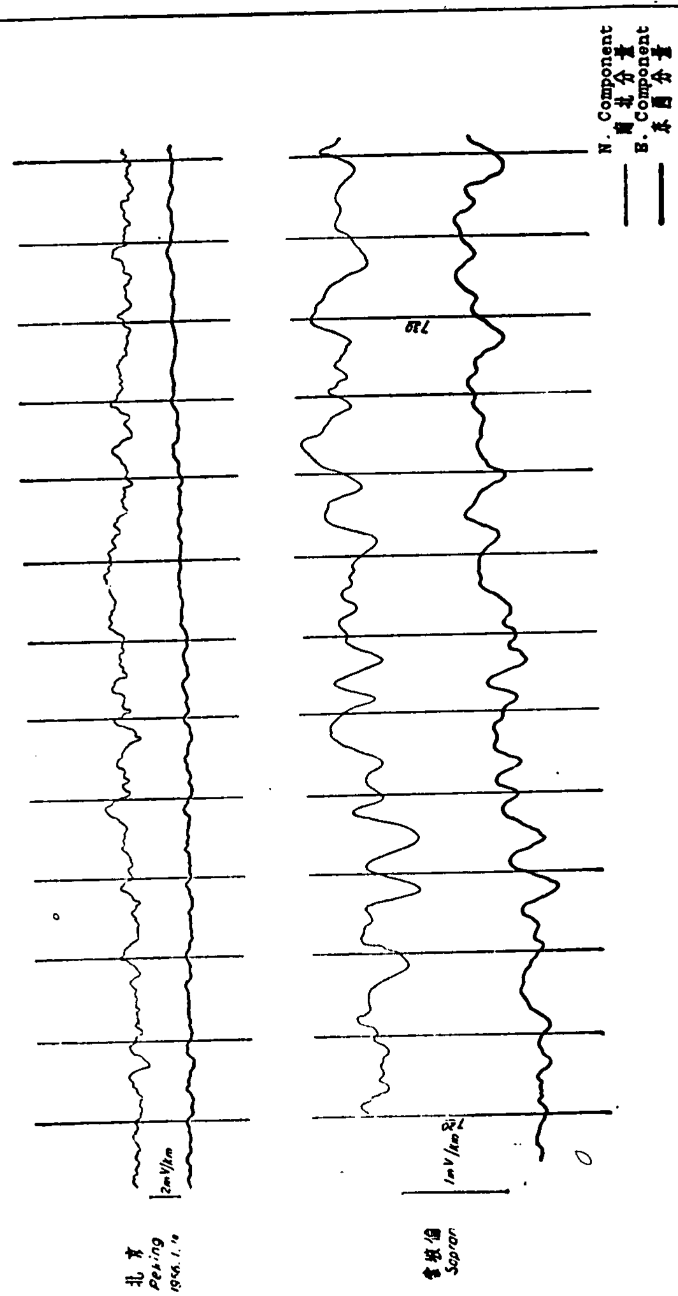

N. Component
南北分量
E. Component
東西分量
2mV/km
1mV/km
北京
Peking
Sopron

圖 2b. (Fig. 2b.)

(2) 用兩個不同的統計方法來研究每十分鐘內的平均強度的變化；

(3) 用簡單的度量法來研究頻率的關係。

一般地說起來，在北京和索坡倫兩處大地電流活動的特徵是一樣的。較長週期的振動都是同時出現。在 1 月 9 日的記錄上（圖 1）兩處的活動都是在 7 點 26 分停止了。還應注意，在北京的記錄上於 7 點 27 分出現的一個一分鐘的變化在索坡倫的記錄上則沒有。如把這個變化和北京的地磁記錄比較當是很有興趣的事。大地電流強度的變化在兩處也同時出現。從 1 月 13 日至 14 日，頻率相同的振盪的幅度顯著的增大了（圖 2a 及 2b）。在記錄的某些部分，從短時間間隔內頻率的度量得出了相同的結果。但這些結果還不能用來作推論和相位的對比。一般地說來，兩處的 20—25 秒的週期符合最佳。

結 果 的 仔 細 分 析

(1) 為了繪製向量圖，1 月 14 日的記錄上每一分鐘的時間間隔內所有的變化都用上了。從這結果可見，在索坡倫的大地電流向量是在轉動，並且轉動的方向也很容易看出來，但是在北京大地電流的方向幾乎是停留在北至東北的方向（圖 3a 及 3b）。（我們願意指出，當我們在中國的山東省作野外工作時也有同樣的經驗）因為我們無從知道北京的電流向量轉動的方向，所以這個參數就無法利用。

(2) 平均強度級曾用兩個法子研究過：

(a) 我們曾把每天 7 點到 8 點之間的總變化向量每十分鐘一次用下列公式求出來：

$$V_x=\int_{t_1}^{t_2}\left|\frac{dX}{dt}\right|dt,\quad V_y=\int_{t_1}^{t_2}\left|\frac{dY}{dt}\right|dt,\ \text{及}\ V=\sqrt{V_x^2+V_y^2}$$

(b) 因為上述的方法強調了快速的變化，所以經 A. 阿達姆的建議我們又使用了下列的方法：

$$T_x=k_x\sum_{n=0}^{i}\left|\int_{t_n}^{t_n+1}dV_x\cdot dt\right|\cdot mV\cdot\text{sec}$$

及

$$T_y=k_y\sum_{n=0}^{i}\left|\int_{t_n}^{t_n+1}dV_y\cdot dt\right|\cdot mV\cdot\text{sec}$$

（自然，$i=10$ 分鐘），

$$T=\sqrt{T_x^2+T_y^2},$$

式中 $k=\Delta V\cdot\Delta t\ mV\ \text{sec/mm}^2$ 是一個計算的係數。這個法子對慢的變化較為有利，但缺點是它對用求積儀積分的誤差和對電極的極化都非常敏感。

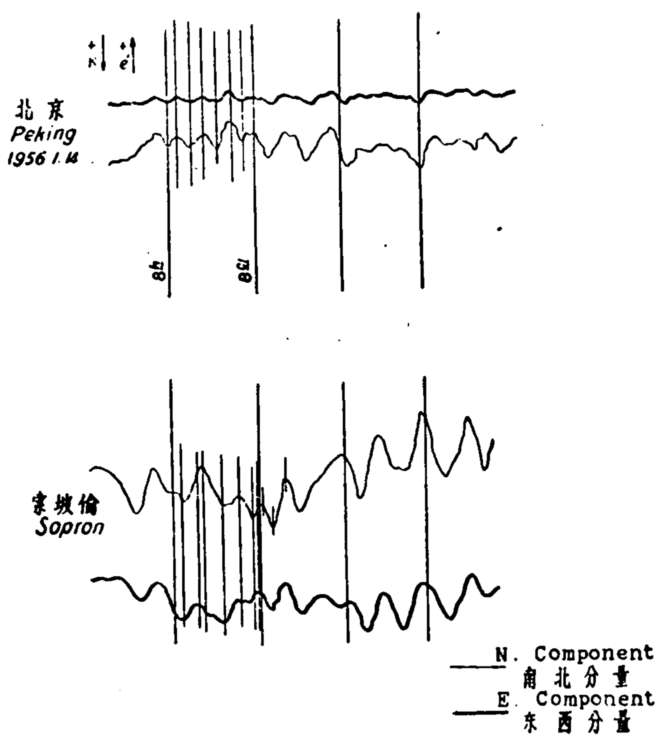


圖 3a.　(Fig. 3a.)

假如我們在每十分鐘內求得全變化，並用來比較這兩處的平均強度級的相對變化，我們可以看出：如除掉少數例外不計，強度級的變化的方向是相同的（圖 4）. 有時候，純粹定性的相似演變成定量的關係；如把這些強度級的變化用百分數表示出來，則兩處的變化相同. 上述我們所看到的也由逐日平均值的曲線來證實了（圖 5）. 這曲線上顯示着在 1 月 10 日兩地的平均值都出現了一個高峯，然後逐漸下降，到 1 月 13 日又開始回升. 從記錄上可以看出強度級的變化主要是和振盪的數目有關. 孔湼森曾證明過，整個地球上大地電流變化的頻帶是和週期為 20 秒的振盪相當. 我們觀測的結果中變化的相似性也證明了這一點.

從總變化向量的逐日平均值我們可以得到相關因數的中間值. $l = \frac{V_{北京}}{V_{索坡倫}} = 4.8$，它的最大偏差是 ±1.4，約合 30%.

當在一處的記錄上看見某種長週期的變化而在另一處的記錄上找不到這種變化

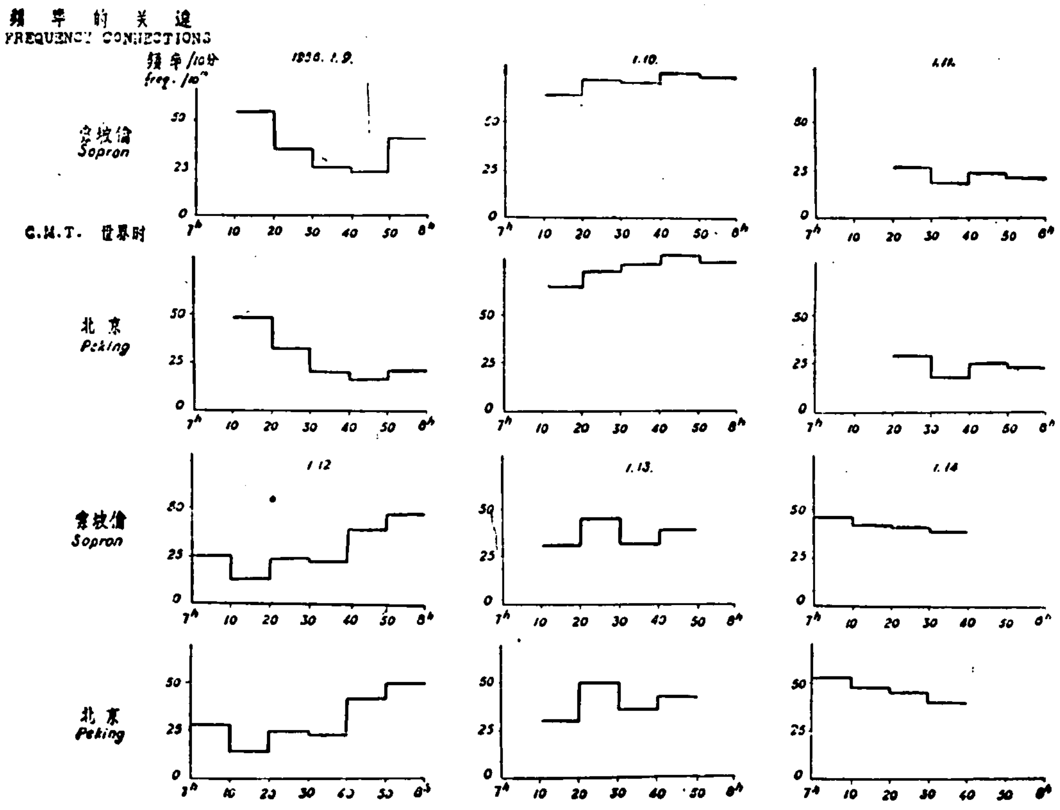


图 8. (Fig. 8.)

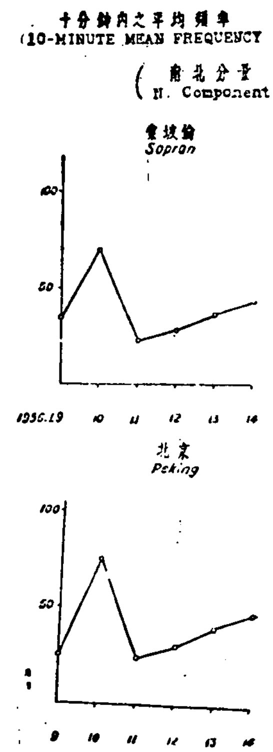


图 9. (Fig. 9.)

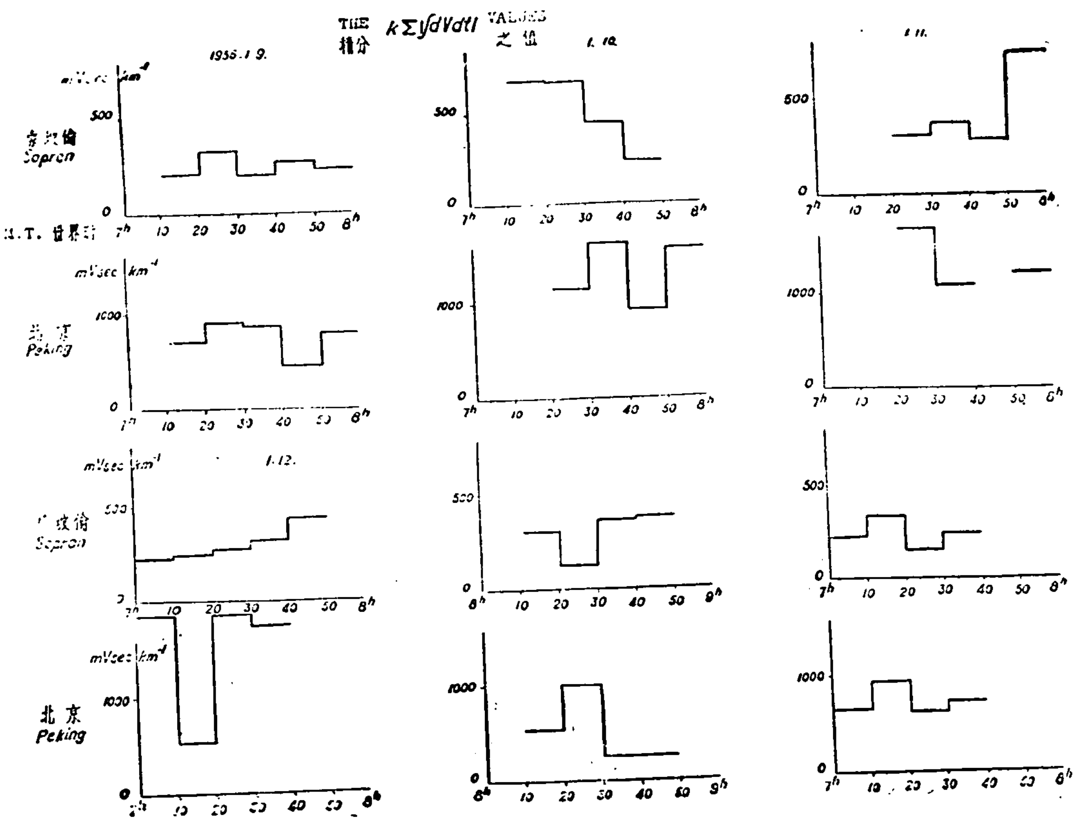
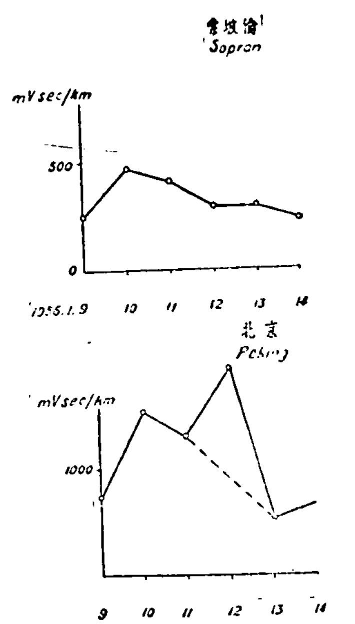


圖 6. (Fig. 6.)



$k\Sigma|\int dVdt|$ DAILY MEAN VALUES 之逐日平均值

圖 7. (Fig. 7.)

十分钟内全变化的平均强度级
10-MINUTE TOTAL VALUE

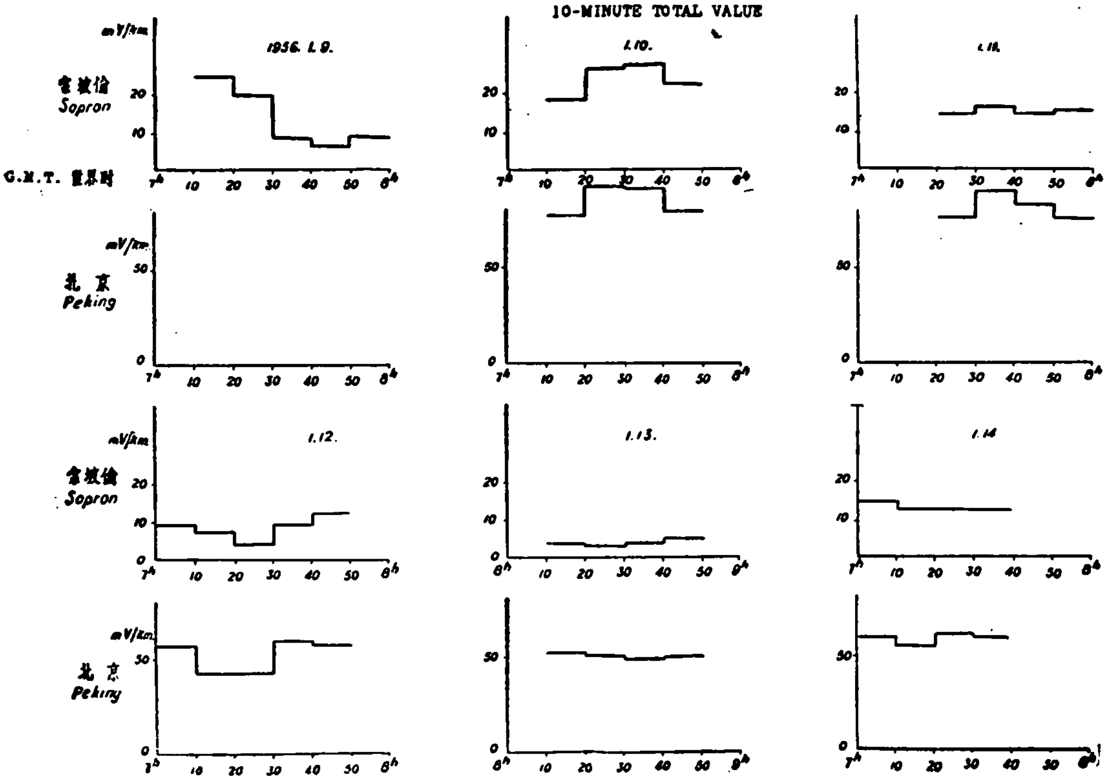
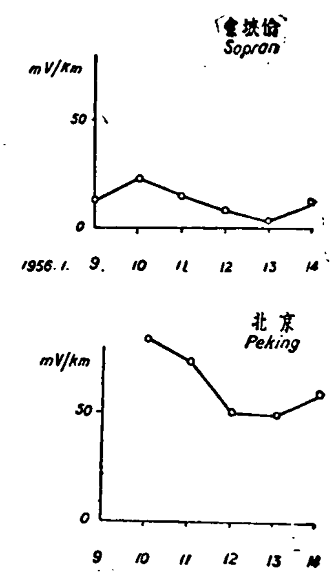


图 4. (Fig. 4.)



总变化逐日平均值
DAILY MEAN OF TOTAL VALUE

图 5. (Fig. 5.)

時．用面積法得的面積法就不能得到很好的關連（圖 6）．強度級的相對變化常常不一樣；並且假如我們把 1 月 12 日在北京得到的結果不算的話，用面積法得的結果在逐日平均值上仍表現了用全變化法所看見的漲落（圖 7）．在其他的幾天則：

$$l' = \frac{V_{北京}}{V_{索坡倫}} = 3.14 \pm 0.19,$$ 這時偏差僅為 6%．

(3) 在相同的時刻也曾數過每 10 分鐘內的振盪數（圖 8）．兩地所得的結果就彌在細節上符合也是很好的．把相對頻率和全變化向量的漲落來比較可以看出：全變化向量的漲落倒底是和頻率的變化有關係還是和振幅的變化有關係．在我們觀測的時期內，頻率數的逐日平均值大體上是和全變化向量的漲落作同樣的變化；這點也支持了以前我們在這方面得到的結論．

根據統計的計算，部分的關連並不是例外的現象，而是有很踏實的和意義深遠的基礎的．從幾天裏度量出來的振盪平均值的變化指明了干擾源的一般影響可以在北京和索坡倫同樣的觀測到；但是因為兩處相隔太遠了，變化的細節只是偶爾相同．

我們這次的研究只注意了振盪的活動性，因為影響能伸展到全球的脈衝式的變化在我們的記錄上並未出現．並且因為觀測的時間很短，我們事先計劃的時候已經放棄了和地方時有關的太陽活動性的觀測．

在北京的觀測是由 A. 阿達姆 和 E. 塔克什兩位工程師作的，中國科學院和中國地質部有幾位同志也曾參加協作．在索坡倫是由 P. 苯茲，F. 柏爾地，B. 儒撒和 P. 埃格則奇等工程師協作作的．

我們很感謝中國科學院為這項研究開闢了道路．我們也很感謝中國地質部的物理探礦局，因為沒有他們的協助和支持這種觀測就不能進行．最後我們還得感謝中國科學院地球物理研究所的趙九章所長，因為他允許我們在北京的地磁台作這些觀測．

［秦馨菱譯］

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